

A NEW SPECIES OF BYTHITID FISH, GENUS *LUCIFUGA*, FROM THE GALÁPAGOS ISLANDS

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ABSTRACT

A new species of bythitid, *Lucifuga inopinata*, is described from an adult female captured in 203 m from a seamount in the SE Galápagos Archipelago. It differs from its congeners in its high pectoral ray and vertebral numbers, as well as having a preopercular spine. Also included are a key to the genus *Lucifuga*, comments on its species, and a discussion of the origin of onshore bythitids.

Among the extraordinary collection of fishes captured during 1995 dives of the research submersible JOHNSON SEA-LINK in the Galápagos Archipelago (McCosker, 1997) was a single female specimen of an undescribed species of bythitid fish that shares characters with two genera. One of them is *Lucifuga* Poey, 1858, known from four valid species from fresh, brackish, and marine waters in Cuba, and one from the Bahamas. The other genus is *Calamopteryx* Böhlke and Cohen, 1966, known from marine habitats in the tropical western Atlantic, where two species have been caught, and at the Galápagos, where a single species is known. Only with knowledge of the male intromittent organ can we assign our new species with total confidence, however the likelihood of capturing another Galápagos specimen is so remote that we herein assign the new species to the genus *Lucifuga*, describe the Galápagos specimen, present a key to the validly described species, comment on several other species, and discuss the possible origins of bythitids that have moved onshore from marine habitats.

MATERIALS AND METHODS

Methods and definitions follow Cohen and Robins (1970) and Cohen and Nielsen (1978). Abbreviations include: ANSP = Academy of Natural Science of Philadelphia; CAS = California Academy of Sciences; FMNH = Field Museum of Natural History; A = anal fin; D = dorsal fin; HL = head length; SL = standard length.

Materials include: the holotype of *L. inopinata*; specimens of *L. dentata*, *L. subterranea*, and *L. spelaeotes* listed in Cohen and Robins (1970); also *L. dentata* from FMNH 52595 (3), 96223 (1), 3933 (1), uncat. (3), and 33086 (1); *L. subterranea* from FMNH 52631 (2), 3934 (1), 33091 (1), 33090 (1), 33093 (1). Material of *Calamopteryx goslinei*, *C. jeb*, and *C. robinsorum* is listed in Böhlke and Cohen (1966) and Cohen (1973).

SYSTEMATICS

Family Bythitidae

Subfamily Brosmophycinae Gill, 1863

Genus *Lucifuga* Poey, 1858

Type species: Lucifuga subterranea Poey, 1858, by subsequent designation of Jordan and Evermann, 1896.

KEY TO SPECIES OF *LUCIFUGA*

The following key depends in part on characters from small samples, which require further validation. We have avoided the use of color and degree of eye development, both of which are known to vary in *Lucifuga* (Eigenmann, 1909; Wilkens et al., 1989).

- 1a. Palatine teeth absent (subgenus *Lucifuga*) 2
- 1b. Palatine teeth present (subgenus *Stygicola*) 3
- 2a. Upper jaw length 6.1–8.7 (7.8) in SL (n = 18); D rays 80–87 (83.2) (n = 18); pectoral fin rays 11–14 (12.1) (n = 18) *subterranea*
- 2b. Upper jaw length 5.4–5.6 in SL (n = 2); D rays 78–80 (n = 2); pectoral fin rays 10–11 (n = 2) *teresinarum*
- 3a. Short, strong, pointed spine at lower angle of preopercle; pectoral fin rays 22; vertebrae 57 ... *inopinata*
- 3b. No spine at lower angle of preopercle; pectoral fin rays 11–20; vertebrae 45–53 4
- 4a. D rays 70–77 (n = 12); A rays 57–60 (n = 12); pectoral fin rays 11–14 *simile*
- 4b. D rays 83–95; A rays 66–78; pectoral fin rays 15–20 5
- 5a. Area between preopercular and lateral head canals naked; pectoral fin rays 15–17 (16.1) (n = 18); vertebrae 46–48 (46.7) (n = 6) *dentata*
- 5b. Area between preopercular and lateral head canals covered with scales; pectoral fin rays 18–20 (n = 2); vertebrae 52–53 (n = 2) *spelaeotes*

***Lucifuga (Stygicola) inopinata* new species**
(Figure 1, Table 1)

Diagnosis.—A short, sharp spine at lower angle of preopercle; pectoral fin rays 22; and vertebrae 14 + 43 = 57.

Description.—Counts: D rays 1 vestigial + 90; A rays 63; caudal fin rays 11; pectoral fin rays 22; ventral fin rays 1–1; vertebrae 14 + 43 = 57; developed gill rakers 3. Measurements in mm: SL 101; HL 30.1; body depth at vent 20.0; upper jaw length 14.0; distance across expanded end of maxillary 4.8; predorsal 35.7; preanal 56.8; left pectoral fin length 18.7 (right 18); ventral fin length 16.5; greatest diameter of eye window 4.4; snout 6.6; and interorbital 6.4.

Dorsal profile descends gently from nape to depressed snout. Lower jaw slightly inferior; ventral profile of head nearly straight. Snout broadly rounded in dorsal view. Body widest at rear of head and highly compressed posterior to vent.

Anterior nostril a tiny pore on upper lip; posterior nostril a prominent oval anterior to eye, with a slightly raised pigmented rim. Small eye occupies only part of prominent, clear, oval window through which it is visible; longest diameter of window less than snout and less than interorbital.

Caudal fin scarcely connected to median fins by a tiny web of skin (variation in this character is noted by Cohen and Robins, 1970; Cohen and Nielsen, 1978; and Díaz Perez, 1988). Dorsal fin highest posteriorly; anal fin about equal in height throughout. Pectoral fin pointed and falling short of vent, its base vertical and mounted on peduncle that is broader than long. Most of pectoral and vertical fin rays branched. Ventral fin inserting below opercle; bases of ventral fin immediately adjacent; each fin comprising a single ray about as long as pectoral fin.

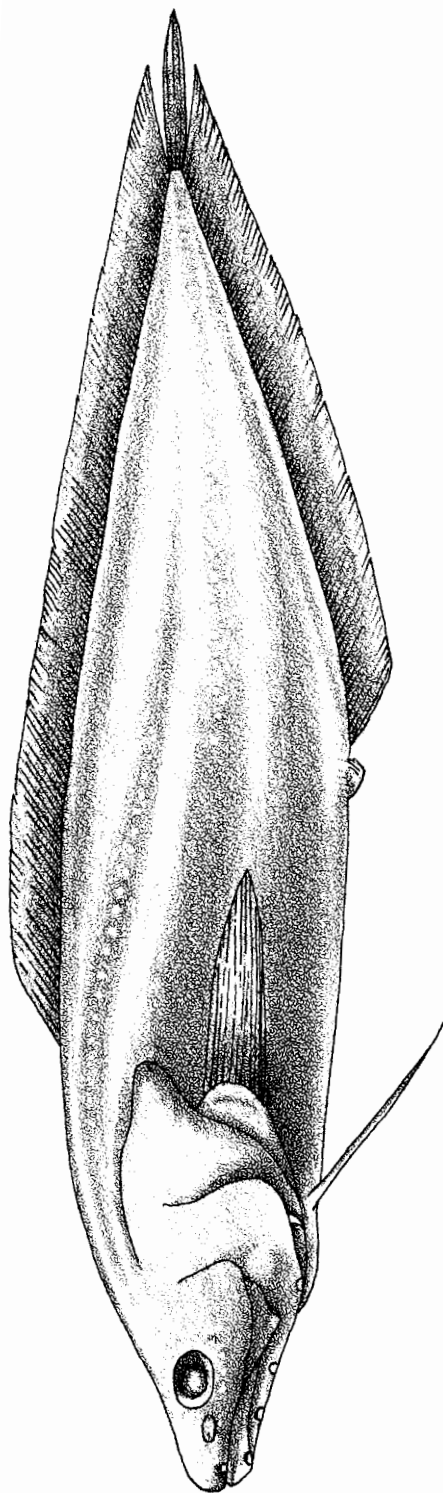


Figure 1. Holotype of *Lucifuga inopinata*, n. sp., CAS 86572, 101 mm SL. Illustration by Molly Brown.

Table 1. Selected character states in *Lucifuga*, *L. inopinata*, and *Calamopteryx*. Data sources are: ¹Cohen and Robins (1970) and Nalbant (in litt.), not including *L. teresinarum*; ²Cohen (1973); ³Cohen and Robins (1970), Díaz Perez (1988), and Díaz Perez et al. (1987a). Data from Díaz Perez et al. (1987b) not included.

	<i>Lucifuga</i>	<i>L. inopinata</i>	<i>Calamopteryx</i>
All or some head canals cavernous	yes	yes	no
Pectoral fin peduncles elongated	no	no	yes
Vertebrae	45–53 ¹	57	37–46 ²
Anal rays	57–78 ³	63	40–57 ²
Spine on preopercle	no	yes	yes

Entire body, including isthmus, pectoral fin base, and all but posterior areas of D and A fin bases covered with small, imbricate, cycloid scales. About one dozen rows of scales, counting obliquely between D fin origin and dorsal-most lateral line. Branchiostegal membranes, underside of head, maxillary and premaxillary, snout, and anterior area of interorbital are naked. Few scales present between posterior nostril and eye and posterior to jaw.

No pored lateral line canal on body; instead there are two series of small, pale papillae. Anterior and dorsal-most series of about 30 papillae extends approximately to level of vent. A ventral series of about 31 (right side 29) papillae extends posteriorly in midline from level of vent but ends about 1/2 head length from base of tail. Very small papillae are distributed on naked areas of snout and mandibles. Suborbital head canals cavernous. Preoperculomandibular canal with at least 6 pores, including: 2 near tip of lower jaw (not connected by a cleft, as Nalbant, 1981, has illustrated for *L. simile*), 3 along mandible, and 1 at lower angle of opercle near sharp spine; more may be along posterior margin of preopercle, but skin is torn. Suborbital pores at least 4:1 at snout, and 3 along flap of skin over maxillary. Supraorbital canal with 1 pore at tip of snout. Lateral canal with single pore above upper angle of opercle.

Developed gill rakers 3:1 at angle of arch and 2 on lower arm. Slit behind 4th gill arch restricted to lower arm. Pseudobranch absent. Tongue narrow and elongate anteriorly. One single blunt pyloric caecum.

Teeth present on premaxillaries, dentaries, palatines and vomer. Premaxillary bears a long band of granular teeth; at anterior end of bone a small inner patch of longer, posteriorly—directed, needle—like teeth. Dentary bears a long band of small granular teeth, similar to those of premaxillary, and flanked by a narrow, internal band of much larger, widely-spaced and posteromedially directed needle-like teeth. Vomer has a narrow band of small, pointed teeth along its external margin and proximal to these about a dozen, larger, needle-like teeth. A single row of sharp-pointed teeth extends along palatine. Opercle carries a sharp, slender, skin-covered spine near upper angle, and preopercle has a strong, sharp, curved, ventrally-directed spine at its lower angle. Posterior end of maxillary broadly expanded and partly sheathed dorsally; a blunt, triangular projection at posteroventral end of bone.

Coloration based on specimen in ethanol.—Orobranchial cavity, peritoneum, and gut pale. Swimbladder is shiny white. Muzzle is dark brown; postorbital part of head paler. Body dark brown except at pale posterior area; (this condition may be due to loss of pigment-bearing scales on both sides of tail). Pectoral and median fins are darker than body, and ventral fins pale.

Etymology.—The name *inopinata* is from the Latin, *inopinus*, unexpected.

Habitat.—The single specimen was captured under a rock ledge using rotenone and a suction tube attached to the submersible. The seamount had a nearly flat sand bottom with 2–3 m tall, large volcanic ledges and blocks that were overgrown with sponges, gorgonians, and lace corals. The temperature at depth was 13.4°C and a 0.5 kn current was apparent. The predominant fish were anthiins, including *Pronotoqrammus eos* and *P. multifasciatus*. Other fishes seen and captured included scorpionfishes (*Pontinus* spp.) and *Serranus stilbostigma*.

Remarks.—Our specimen is a female, and although it clearly represents an undescribed species it cannot be precisely allocated to a genus without examination of a male, as the intromittent organ contains a suite of important taxonomic characters (Cohen and Nielsen, 1978). If we assume that the male intromittent organ of *inopinata* lacks ossified parts, the specimen is easily identified as a species of *Lucifuga*, which it resembles in general appearance. However, the specimen differs from *Lucifuga* and resembles *Calamopteryx* in possessing a strong, sharp spine at the lower angle of the preopercle. *Calamopteryx* has the pectoral fin carried on an elongate pectoral peduncle with long pectoral radials; *inopinata* resembles *Lucifuga* in having a short pectoral fin support.

A relationship between *Lucifuga* and *Calamopteryx* has been suggested by Cohen and Robins (1970), and Vergara (1980) used a numerical scheme to analyze the phylogeny of two species of *Calamopteryx* and three species of *Lucifuga* and concluded that the two genera are monophyletic brother groups (sic) with a common ancestor.

Whether to recognize one, two, or three genera cannot be decided with certainty until a male specimen of *inopinata* is available. For the present we recognize both *Lucifuga* and *Calamopteryx* and tentatively assign the new species to the former. Table 1 shows that in four out of five characters, *inopinata* is closer to *Lucifuga* than to *Calamopteryx*.

Material examined.—Holotype: CAS 86572, 101 mm SL, a female, collected on a seamount SE of San Cristobal Island (01°06.4'S, 89°07.0'W), in the Galápagos Archipelago, Ecuador, at 203 m, on 6 November 1995 by J. E. McCosker and party using the submersible JOHNSON SEA-LINK.

Lucifuga (L.) *subterranea* Poey, 1858

L. subterranea lives in southwestern Cuba, sympatrically in the eastern part of its range with *L. dentata* and *L. teresinarum* (Eigenmann, 1909; Vergara, 1981). The best account of its habitat and biology is that of Eigenmann (1909), who describes the various caves, sinkholes, and crevasses in the raised limestone shelf in which these fishes are found. Although the water is described as fresh, Eigenmann (1909:200) writes, "The water is everywhere highly charged with salts of lime and magnesium." Eigenmann (1909) also describes considerable variation in the development of the eye, which is more prominent in younger fishes, and of body pigmentation, "which varies from pink to lilac-pink and lilac," with an increase in pigment with age.

Lucifuga (L.) teresinarum Díaz Perez, 1988

L. teresinarum is based on two specimens, each from a different cave, where it is found sympatrically with *L. subterranea* and *dentata*. Both examples are a pale pinkish color and have vestigial eyes.

Lucifuga (S.) simile Nalbant, 1981

L. simile was described from two females caught in a cave in Matanzas Province, Cuba. Twelve males and four females from the type locality and two additional localities are reported by Díaz Perez et al. (1987a), who also present data on inter- and intraspecific variation as well as sexual dimorphism.

Díaz Perez et al. (1987a) also mention salinities ranging from fresh water to 22 ppm, and the co-occurrence of *L. simile* with *L. subterranea*, *Eleotris*, and *Macrobrachium* as well as two primitive crustaceans, a thermosbaenacean and *Thaumatoctypris*, an ostracode.

Lucifuga (S.) dentata Poey, 1858

L. dentata, also known in the literature as *Stygicola dentata* (Cohen and Robins, 1970, reduced *Stygicola* Gill, 1863, to subgeneric rank), is apparently the most common and widely distributed of the Cuban *Lucifuga* species, living on both the north and south slopes of west-central Cuba. It is known to co-occur with *L. subterranea* and *teresinarum* (Vergara, 1981; Díaz Perez, 1988). As in *subterranea*, the eye is less well developed in older fish. Individuals vary in color, from pinkish-lilac to steel-blue, but unlike *subterranea*, pigmentation does not increase with age. Dark and light-colored fish live together (Eigenmann, 1909).

L. (S.) spelaeotes Cohen and Robins, 1970

The Bahamian species, *L. spelaeotes*, was described from two specimens collected in 1967 from a roughly inverse conical, brackish water sinkhole on New Providence Island. In 1973 DMC (through the kindness of Dr. James E. Böhlke and the Academy of Natural Sciences of Philadelphia) was able to visit the type locality, known locally as Mermaid's Pool. He found the water structure consisting of a warmer, low salinity layer to a depth of about 4 m, where a density discontinuity was marked by a pseudo-bottom of waterlogged leaves and twigs; beneath this boundary layer the water was clearer, colder, and more saline. *Lucifuga* specimens were present in the upper layer. Both dark and light-colored fish hung close to the sloping walls of the sink. When a fish was touched it swam rapidly away, sometimes colliding with the side; when driven into midwater, fishes appeared disoriented and were easily netted. *L. spelaeotes* has been discovered at other localities on New Providence Island (data on file at ANSP). The genus is apparently widely distributed in the Bahamas, with specimens seen or captured in blue holes and caves on Grand Bahama, where *Lucifuga* were found by Yager (1981) in darkness at a depth of 19 m in salt water, with primitive crustaceans belonging to the Remipedia and Thermosbaenacea. Palmer (1985) also reported blind, pale, pink fish living in total darkness at depths to 21 m in salt

water, in some instances with remipeds and thermosbaenaceans, and Smith-Vaniz and Böhlke (1991) report them from Lucayan Cavern on Grand Bahama. Fishes reported as *Lucifuga* have been sighted in sea caves on Andros, on one dive together with the marine bythitid *Oligopus*, and in a shallow ocean cave in Exuma at depths of 3 and 10 m (B. Kakuk, in litt.). They have also been found in an inland sinkhole on Abaco and on Long Island (Smith-Vaniz and Böhlke, 1991, and J. Yager, in litt.).

OTHER CUBAN *LUCIFUGA*

The first *Lucifuga* from eastern Cuba was collected in a cavern in Holguín Province. The specimen, a female with reduced eyes, was taken at a depth of 12 m and salinity of 16 ppm (Díaz Perez et al., 1987b). Although the specimen is said to lack palatine teeth, which would place it in the subgenus *Lucifuga* with *subterranea* and *simile*, the authors designated it as the holotype of *Lucifuga dentata* variety *holguinensis*. Aside from its putative relationships, *holguinensis* was proposed as an infrasubspecific category and is therefore excluded from zoological nomenclature [International Code of Zoological Nomenclature, 3rd ed., 1985, art.1 (b) (5); art 16; art. 45 (g)].

Díaz Perez et al. (1987b) also reported on a large (156 mm SL) male with reduced eyes from a depth of 20 m in a cavern in western Cuba which had stratified salinity increasing to 34 ppm at the 40 m bottom. This specimen is reported as having palatine teeth and is identified as *L. dentata*. Although the authors presented data from the specimen they did not further discuss its very high D count of 123 (the next highest are D 83–95 in *L. dentata* and D 92–95 in *L. spelaeotes*) and A count of 111 (A 66–78 in *L. dentata*). If this specimen is in fact *Lucifuga* it would seem to represent yet another Cuban species.

DISCUSSION

A bythitid invasion of onshore habitats with varying salinity appears to be an ongoing evolutionary process. Wilkens et al., (1989) have attempted to correlate degeneration of the eye in *Lucifuga* and *Ogilbia* with the geologic time of onshore migration (Wilkens et al., 1989). That invasion contrasts with the situation in several groups of disjunct but widely distributed crustaceans with which *Lucifuga* coexists and that are considered ancient and relict (Iliffe et al., 1984). So far as known, bythitids have come ashore at three areas (Wilkens et al., 1989), all in the New World tropics. One area is Cuba and the Bahamas, where *Lucifuga* is moving from a nearshore marine habitat to onshore ones with a considerable range of salinities, to the apparent exclusion of the local reef-dwelling bythitid *Ogilbia*. Interpreting the pattern of speciation and sequence of onshore invasions of *Lucifuga* in this region would benefit from studies in comparative biology and molecular systematics. Wilkens et al. (1989) suggest that a comparative study of eye development might prove fruitful.

Inland caves and cenotes in the Karst topography of the Yucatan Peninsula are the home of at least one pale, eyeless species of *Ogilbia* (*O. pearsei*), also in the literature as *Typhlias pearsei* and *Typhliasina pearsei* (Cohen and Nielsen, 1978; Hubbs, 1938; Reddell, 1977; J. Yager, in litt). If *Lucifuga* was present during the Pliocene when uplift of this region occurred (Wilkens et al., 1989; A. Fischer, pers. comm.), it was apparently excluded by *Ogilbia*.

The third invasion is taking place on Santa Cruz Island in the Galápagos, where *Ogilbia* has apparently excluded marine *Lucifuga*. Two closely-related species of *Ogilbia* (also in the literature as *Caecogilbia*; see Cohen and Nielsen, 1978) are found. One is a marine reef dweller; the other lives in brackish water at the bottom of crevasses and holes in the basaltic substrate (Van Mol, 1967) and varies in pigmentation and eye development.

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